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GERMINATION OF VARIOUS CONIFEROUS SEEDS AFTER COLD STORAGE

G. H. Schubert, Forester,
Division of Forest Management Research

Most conifers do not bear seed each year, but rather at intervals, with good crops occurring two to ten years or more apart. It is necessary, then to collect seed during good seed years to tide over the poor years. How long seed may be stored safely is thus of great practical importance. This article reports results of germination tests on seed of various conifers stored by this Station from 2 to 24 years. The seed includes some lots previously tested (table 1), and some tested for the first time in 1951 (table 2).

Storage Conditions

Seeds were air-dried immediately after being collected and extracted, and then stored in airtight containers at 41° F. The containers were 5-gallon cans with tight lids. Generally seed of more than one species and a number of different seed lots were stored in a single can. This may not be the best procedure to follow because the can may be opened several times to get seed of different species or lots. Exposing the seed in this way may not be harmful if the relative humidity of the storage room is low and the cans are closed as quickly as possible. Still, it is believed that properly stored seed might give somewhat higher germination than is reported here. By properly stored seed is meant that the following conditions have been fulfilled:

1. Seed is not collected until ripe.

2. Seed is dried to 6 to 10 percent moisture content, depending on the species.

3. Cold storage starts as soon after drying as possible.

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* MAINTAINED AT BERKELEY, CALIFORNIA, IN COOPERATION WITH THE UNIVERSITY OF CALIFORNIA.

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4. Containers are airtight and of a size which will hold the average amount of seed used at any one time.

5. Storage temperature is in the range of 5° to 32° F. and not higher than 41° F.[1]

6. Seed is used as soon as possible after removal from cold storage.[1]

The above conditions have generally been complied with at this Station, except items 4 and 5 and in a few instances, item 1. These exceptions have been noted above and in "Results" where several cases are mentioned in which the seed was believed to be immature at time of collecting.

Wakeley[1] suggests that properly dried conifer seed, such as longleaf, slash, loblolly, and shortleaf pines, can be stored in bags instead of airtight containers if humidity in the cold storage space is low and constant.

Stratification and Germination Tests

Representative samples of 100 to 400 seeds of each species and seed lot tested were stratified in moist sand and peat moss for 60 days at 36° F. This period of 60 days might have been too short for some species, such as sugar pine and possibly the other white pines, which were in cold storage for an extended time. It is generally recommended that sugar pine should be stratified for 90 days or more to obtain maximum germination. Some of the species, such as ponderosa and Jeffrey pine, may not require stratification. However, it was believed that stratification would do no harm and might possibly be beneficial.

Germination tests were conducted in the greenhouse in the same containers (4-inch waxed paper pots) used for stratification. The greenhouse temperature varied from about 55° F. at night to 75° F. at day. The germination tests were closed at the end of 12 weeks. Almost all seed samples had stopped germinating by the end of the ninth week. No germination occurred during the last two weeks. No cutting test was made on the ungerminated seed; therefore, the germinative capacities listed in Tables 1 and 2 are based only on seed which actually germinated.

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[1] Wakeley, Philip C. 1951. Storing southern pine seed. U. S. Dept. Agr. Forest Service, Southern Forest Experiment Station Occasional Paper 123. 13 p. New Orleans, Louisiana.

Table 1.- Germination of various coniferous seeds after prolonged cold storage

Species	Year collected	Years in cold storage[1]	Original germination capacity	Other record of germination: Percent	Other record of germination: Date	Germination capacity 1951
Abies concolor	1937	14	[2] 4	--	--	0
A. concolor	1938	13	[2] 21	--	--	0
A. grandis	1935	16	[2] 8	--	--	0
A. lasiocarpa	1937	14	[2] 9	--	--	0
A. magnifica	1935	16	--	[2] 8	1938	8
A. nobilis	1938	13	[2] 25	--	--	1
Cupressus forbesii	1939	12	[2] 17	--	--	12
Picea englemannii	1937	14	[2] 24	--	--	0
P. pungens	1933	18	--	[2] 56	1937	0
Pinus albicaulis	1936	15	[2] 75	[2] 28	1937	3
P. attenuata	1935	16	--	[3] 69	1945	87
P. balfouriana	1935	16	[3] 86	[3] 72	1945	95
P. canariensis	1933	18	[3] 20	[3] 13	1945	12
P. contorta	1934	17	[3] 91	[3] 77	1945	47
P. contorta	1935	16	[3] 55	[3] 48	1945	40
P. contorta var. latifolia	1934	17	--	[2] 54	1938	47
P. contorta var. latifolia	1935	16	--	[3] 58	1945	28
P. jeffreyi	1933	18	[3] 61	[3] 24	1945	62
P. jeffreyi	1936	15	[3] 65	[3] 67	1945	64
P. lambertiana	1930	21	[3] 26	[3] 8	1945	10
P. lambertiana	1936	15	[2] 31			50
P. lambertiana	1933	18	[3] 93	[3] 32	1945	30
P. lambertiana	1935	16	[3] 77	[3] 13	1945	20
P. lambertiana	1948	3	[4] 90	[5] 65	1950	10
P. monticola	1935	16	--	[3] 44	1945	35
P. monticola	1936	15	[3] 62	[3] 66	1945	40
P. patula	1930	21	[3] 60	[3] 39	1945	61
P. pinea	1933	18	--	[3] 58	1945	32
P. ponderosa	1933	18	--	[3] 90	1945	94
P. ponderosa	1934	17	[3] 72	[3] 76	1945	75
P. ponderosa	1936	15	[2] 59	--	--	46
P. ponderosa	1936	15	[3] 63	[3] 49	1945	32
P. ponderosa	1935	16	--	[2] 84	1937	28
P. ponderosa	1937	14	[2] 56	--	--	50
P. radiata	1930	21	[3] 94	[3] 81	1945	86
P. radiata	1934	17	[3] 78	[3] 36	1945	27
P. radiata	1935	16	--	[3] 71	1945	66

Footnotes at end of table, next page.

Continued next page

Table 1.- Continued

Species	Year collected	Years in cold storage [1]	Original germination capacity	Other record of germination		Germination capacity 1951
				Percent	Date	
Pseudotsuga macrocarpa	1932	19	[3]34	--	--	2
P. macrocarpa	1934	17	--	[2]38	1938	0
P. macrocarpa	1934	17	--	[2]57	1938	1
P. taxifolia	1935	16	--	[2]27	1938	31
Sequoia gigantea	1937	14	[2]18	--	--	8
S. gigantea	1938	13	[2]21	--	--	46
S. sempervirens	1934	17	--	[2]0	1939	1
S. sempervirens	1935	16	--	[2]14	1938	0

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[1] Stored in airtight 5-gallon cans at 41° F.

[2] From unpublished germination records of James Roof, nursery technician, California Forest and Range Experiment Station 1937-39.

[3] Source: Mirov, N. T. 1946. Viability of pine seed after prolonged cold storage. Jour. Forestry 44(3): 193-195.

[4] From unpublished germination results by the author in the winter of 1948-49.

[5] Source: Fowells, H. A., and G. H. Schubert. 1951. Recent direct seeding trials in the pine region of California. U. S. Dept. Agr. Forest Service, California Forest and Range Experiment Station Research Note No. 78. 9 p. Berkeley, California.

Table 2.- Germination capacity of stored coniferous seeds for which no previous germination records are available

Species	Germination capacity when length of storage was--			
	0-5 years	6-10 years	11-20 years	21 years and over
	Percent[1]			
Abies concolor	53(1)	0-6(3)	0-8(10)	6(1)
A. magnifica	--	24(1)	0-2(2)	--
A. nobilis	--	--	2(1)	--
Cedrus libani	48(1)	--	--	--
Chamaecyparis lawsoniana	--	--	0-13(2)	--
Cupressus arizonica	--	--	0-35(3)	--
C. bakeri	--	--	10(1)	--
C. forbesii	--	--	16(1)	--
C. goveniana	--	--	53(1)	--
C. lusitanica	--	--	--	10(1)
C. macnabiana	--	--	18(1)	--
C. nevadensis	--	--	18(1)	--
C. pygmaea	--	--	17-66(2)	--
C. sargentii	--	--	9-15(2)	--
Larix dahurica koreana	--	--	2(1)	--
L. occidentalis	--	--	5(1)	--
Libocedrus decurrens	74-98(2)	0(1)	0(1)	--
Picea sitchensis	--	68(1)	2-6(2)	--
Pinus attenuata	--	--	71-76(2)	--
P. brutia	8(1)	--	--	--
P. jeffreyi	76(1)	68-88(2)	51(1)	--
P. lambertiana	--	--	2-56(3)	0(1)
P. laricio var. salzmannii	--	--	1-6(2)	--
P. monticola	--	--	20-30(2)	--
P. ponderosa	61-86(2)	--	41-87(5)	--
P. radiata	94(1)	--	--	--
P. strobus	--	--	0(1)	--
P. thunbergii	--	--	8(1)	0(1)
P. torreyana	94(1)	--	--	--
Pseudotsuga taxifolia	--	66(1)	0-15(3)	--
Sequoia gigantea	--	58(1)	0-68(6)	--
S. sempervirens	2(1)	0(1)	0(6)	--
Tsuga heterophylla	--	--	1-13(2)	--
T. mertensiana	--	--	0-2(2)	0(1)

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[1] Numbers in parentheses indicate the number of seed lots represented.

Results

Seed of Abies and Libocedrus had low viability after 3 to 6 years in storage (tables 1 and 2). This agrees fairly well with previous reports[2] that seed of these genera lose most of their viability in the relatively short time of 4 to 5 years. One seed lot of Abies concolor, however, retained 53 percent viability after 3 years and two seed lots retained 6 to 8 percent after 16 and 21 years. Two seed lots of Libocedrus decurrens retained 98 and 74 percent viability after 2 and 3 years; however, all lots of this species stored for more than 8 years had lost all viability.

Seed of Cupressus and Pinus kept very well over a prolonged period. This was especially true of the closed-cone pines, Pinus attenuata, P. radiata, and P. contorta. Several seed lots of P. attenuata retained a viability of 71 to 87 percent after 16 to 17 years, and one seed lot of P. radiata still had a viability of 86 percent after 21 years, an indicated loss of only 8 percent. Several seed lots of P. contorta, stored for 16 and 17 years, had 40 to 47 percent viability. One seed lot of P. contorta, which had an original viability of 91 percent, lost only 14 percent during the first 11 years, but lost 30 percent during the next 6 years. Another seed lot, of the same species, had a viability of 58 percent at the end of 10 years, then dropped to 28 percent at 16 years. On the basis of these two seed lots, there is some indication that the rate of viability loss increases after 10 or 11 years. The various species of Cupressus (table 2) retained their viability for 11 to 21 years. The only exception was the seed lot collected in 1940, which had lost all viability in 11 years. This particular seed lot was believed to be immature when collected.

Not all species of the same genus store equally well. One of the best examples of this is in the genus Sequoia. Sequoia gigantea is generally known to retain its viability better than S. sempervirens. Two seed lots of S. gigantea still had 41 and 43 percent viability after 16 and 17 years. None of the seed lots of S. sempervirens had more than 1 percent viability at a comparable storage period. Another example is in the genus Pseudotsuga. One seed lot of P. taxifolia had a viability of 66 percent after 6 years and another had 31 percent after 16 years. None of the seed lots of P. macrocarpa, however, retained much viability after 4 years. One sample of the latter had 2 percent viability after 19 years.

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[2] Forest Service. 1948. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654. 416 p. illus.

The genera *Chamaecyparis*, *Larix*, and *Tsuga* were represented by only one or two species. In general, they had low viability after 15 years. One seed lot of *Chamaecyparis lawsoniana* and one of *Tsuga heterophylla* had 13 percent after 16 and 15 years respectively. The best result for *Larix* was for *L. occidentalis* which had 5 percent after 16 years. Very few reports on viability after prolonged storage are available for these genera.

In general, the results show that seed of most conifers can be collected in large quantities during good seed years with assurance that they will retain high viability for intervals sufficiently long to tide over the poor seed years--providing the seed is properly handled and stored.

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